Geophysical Data Fusion for Subsurface Imaging

Developer: Coleman Research Corporation
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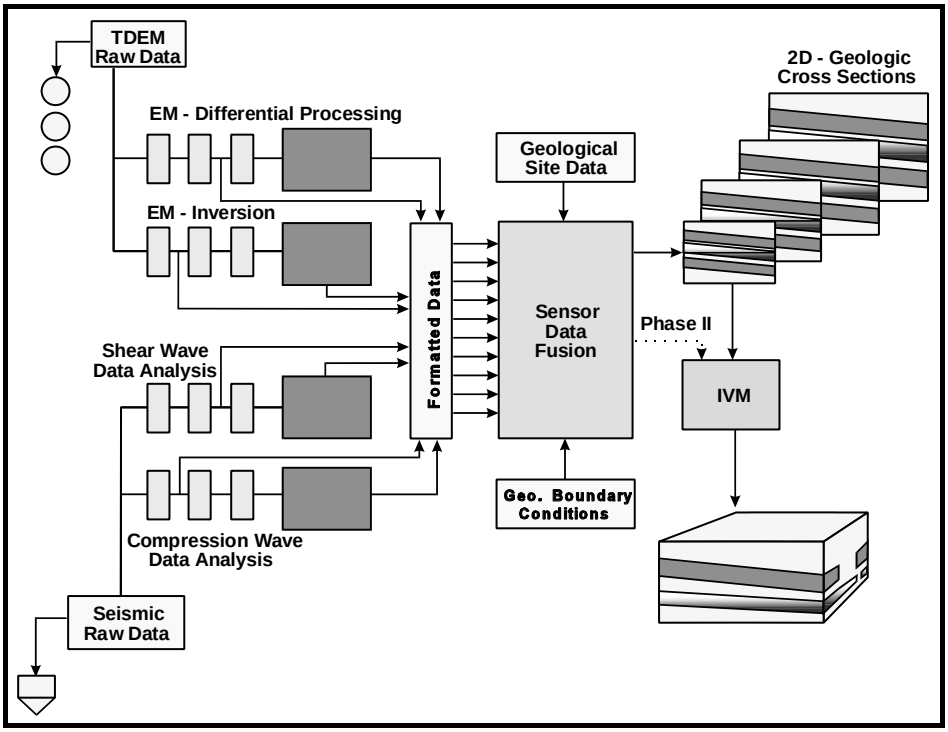
Crosscutting Area: CMST

Subsurface Contaminants FOCUS AREA



Problem:

No software package currently exists for use in a workstation for geophysical data fusion for subsurface imaging. Measuring and imaging several hundred feet of depth of highly stratified geologies with thin (less than three feet thickness) and discontinuous clay layers intermixed with unconsolidated sediment is currently not accomplished by any single or multiple geophysical surface sensor. Most often the only reliable alternatives for defining such complicated profiles are expensive and time consuming logging of closely spaced exploration wells, and down-hole geophysical detection.

Solution:

Develop and demonste a fundamental sensor fusion methodology that leverages synergism between dissimilar sensors and explicitly incorporates geophysical understanding to obtain the best possible subsurface image. A physical motivation for sensor fusion is that different sensors for subsurface imaging depend on different physical principles and, thus have widely varying characteristics (e.g., seismic and EM sensors). Fusion offers the potential for the sensors to bootstrap each other for better performance than they can individually achieve. Another motivation for fusion is that the combination of physical information with sensor information may provide a delineation of the geology which is much better than with sensor information alone.

Benefits:

- 3D subsurface images over a wide region outside that of known geological structure
- Evaluation of fusion methodology and seismic sources
- Accessible to people with minimal training in data fusion technology
- Wide applicability to sites with environmental management needs
- Usable offsite through computer terminal

Technology:

A prototype fusion workstation has been developed that processes multiple sensor data with sufficient fusion automation to be accessible to engineers with minimal training in data fusion technology. The software will be used for characterization of hazardous waste sites by delineation of contaminant plumes and by identification of thin clay layers and geological discontinuities up to a depth of 300 feet. Fusion methodology may have wide applicability to the numerous sites that have environmental management needs.

Fusion methodology has been applied to Time Domain Electromagnetics (TDEM) and seismic data with the goal of obtaining shallow, high-resolution subsurface images. It combines non-invasive geophysical sensors including TDEM and near surface seismic exploration techniques. A high frequency seismic source is used to identify thin strata, while algorithms will be developed for differential processing of TDEM which will result in a three-dimensional display.

The main elements of a fundamental data fusion system have TDEM and seismic data processed separately to provide inputs to sensor data fusion. Current TDEM subsurface images are obtained by an electromagnetic (EM)-inversion process that adjusts the image until it is consistent with the data. Fundamental sensor fusion adjusts the image until it is simultaneously consistent with data from all the sensors. EM inversion uses pre-processed data rather than raw data in the inversion steps leading to a geologic cross section. Fundamental sensor fusion uses the same pre-processed data as EM inversion and also uses pre-processed data from other sensors. In addition, sensor fusion may use geologic cross sections from individual sensors to initialize fusion processing. Geological site conditions and geophysical boundary conditions are also used in the fusion process.

The fundamental sensor fusion approach combines data from complimentary sensors with explicit geophysical understanding to form a subsurface image. Information contained in the data is directly combined with physical information to form the best image.

Project Conclusion:

This project was completed in December 1995. Prior to project completion, extensive field testing was conducted at Savannah River. At project completion, Savannah River purchased the software to continue to implement definition of deep subsurface strata and provide more cost effective rationale for future monitoring and remediation activities. Other site applications include Fernald, Hanford, Pantex (Texas), and a former Manufactured Gas Plant in Marshalltown, Iowa.

In the near future, this technology is expected to be used for the Army Environmental Center (AEC) at the Letterkenney, Pennsylvania Depot with 3-D reconstruction of stratigraphy and structure for input to a flow and transport simulation. Related market interest has been favorable at DOE, DOD, and private industry.

Contacts:

Coleman has been successful in the development and prototyping of sensor and signal processing hardware/software for geophysical modeling. This technology is now being applied to the DOE's environmental restoration programs. For information on this project, the contractor contact is:

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DOE's Morgantown Energy Technology Center supports the Environmental Management - Office of Science and Technology by contracting the research and development of new technologies for waste site characterization and cleanup. For information regarding this project, the DOE contact is:

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